HE
18.5
.A34
no.
DOT-
TSC-
NHTSA-
79-6

O. DOT-TSC-NHTSA-79-6

HS-803-835

RFORMANCE CHARACTERISTICS OF AUTOMOTIVE ENGINES IN THE UNITED STATES

Third Series - Report No. 6
1978 Volkwagen Diesel, 90 CID (1.5 Liter), F.I.

D.E. Koehler
W.F. Marshall

U.S.DEPARTMENT OF ENERGY
BARTLESVILLE ENERGY TECHNOLOGY CENTER
P.O.Box 1398
Bartlesville OK 74003

DEPARTMENT OF
TRANSPORTATION
APR 11 1979
LIBRARY

FEBRUARY 1979

INTERIM REPORT

DOCUMENT IS AVAILABLE TO THE PUBLIC
THROUGH THE NATIONAL TECHNICAL
INFORMATION SERVICE, SPRINGFIELD,
VIRGINIA 22161

Prepared for

U.S. DEPARTMENT OF TRANSPORTATION
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION
Office of Research and Development
Washington DC 20590

NOTICE

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no liability for its contents or use thereof.

NOTICE

The United States Government does not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the object of this report.

HE
18.5
.A34 no. DOT-TSC-NHTSA-79-6

Technical Report Documentation Page

1. Report No.
HS-803-835

2. Government Accession No.

3. Recipient's Catalog No.

4. Title and Subtitle
PERFORMANCE CHARACTERISTICS OF AUTOMOTIVE ENGINES
IN THE UNITED STATES, Third Series - Report No. 6
1978 Volkswagen Diesel, 90 CID (1.5 Liter), F.I.

5. Report Date
February 1979

6. Performing Organization Code
✓

7. Author's)
D.E. Koehler and W.F. Marshall

8. Performing Organization Report No.
~~BETC/OP-78/33~~
DOT-TSC-NHTSA-79-6

9. Performing Organization Name and Address
U.S. Department of Energy*
Bartlesville Energy Technology Center
P.O. Box 1398
Bartlesville OK 74003

10. Work Unit No. (TRAIS)
HS927/R9404

11. Contract or Grant No.
RA-77-07

12. Sponsoring Agency Name and Address
U.S. Department of Transportation
National Highway Traffic Safety Administration,
Office of Research and Development,
Office of Passenger Vehicle Research,
Technology Assessment Division Washington DC 20590

13. Type of Report and Period Covered
Interim Report
July 1978

14. Sponsoring Agency Code

15. Supplementary Notes
*Interagency agreement with:
U.S. Department of Transportation
~~Research and Special Programs Administration~~
Transportation Systems Center
Kendall Square, Cambridge MA 02142

16. Abstract

Experimental data were obtained in dynamometer tests of a 1978 VW 90 CID engine to determine fuel consumption and emissions (hydrocarbon, carbon monoxide, oxides of nitrogen) at steady-state engine operating modes. The objective of the program is to obtain engine performance data for estimating emissions and fuel economy for varied engine service and duty. The intent of the work is to provide basic engine characteristic data required as input for engineering calculations involving ground transportation.

DEPARTMENT OF
TRANSPORTATION
APR 11 1979
LIBRARY

17. Key Words
Fuel Economy
Auto Emissions

18. Distribution Statement
DOCUMENT IS AVAILABLE TO THE PUBLIC
THROUGH THE NATIONAL TECHNICAL
INFORMATION SERVICE, SPRINGFIELD,
VIRGINIA 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	42	

PREFACE

This report, prepared by the U.S. Department of Energy, Bartlesville Energy Technology Center for the U.S. Department of Transportation, Transportation Systems Center, Energy Technology Branch, Cambridge MA, presents results of experimental work to obtain information on performance characteristics of an engine used in automobiles sold in the United States. The VW 90 CID (diesel) engine used in this work is one of a series of 15 engines to be tested in the current program. This is the sixth of the reports to be published covering work with those engines.

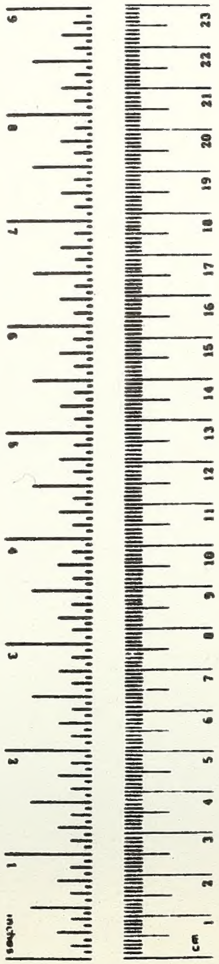
This project is funded by the National Highway Traffic Safety Administration, Office of Research and Development, Office of Passenger Vehicle Research, Technology Assessment Division.

James A. Kidd, Jr. and Ralph G. Colello of the U.S. Department of Transportation, Transportation Systems Center, are the technical monitors.

METRIC CONVERSION FACTORS

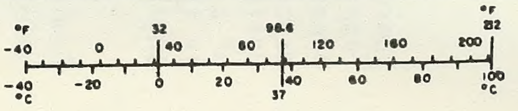
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



1. INTRODUCTION

The objective of the program is to obtain engine performance data for estimating fuel economy and emissions for varied engine service and duty. The intent of the work done at Bartlesville Energy Technology Center is to provide basic engine characteristic data required as input for engineering calculations of fuel consumption and emissions involving ground transportation.

The data acquired from tests of a 1978 VW 90 CID engine are presented in this report. Volkswagen uses the 90 CID diesel engine in the VW Rabbit weighing in the 2,250 lb weight class. The engine as equipped is intended for use in a forty-nine state (Federal) vehicle with manual transmission. The test results are sufficient to establish steady-state maps for fuel consumption and emissions (carbon monoxide, unburned hydrocarbons, and oxides of nitrogen) over the entire operating range of the engine.

2. ENGINE TEST REPORT

The engine test setup included a complete engine (SAE definition) coupled to an eddy-current dynamometer. A cooling tower was used in place of the fan and radiator. The alternator was included but was not wired into the engine's electrical system. The manufacturer's engine specifications are listed in Table 1.

Prior to testing, engine break-in consisted of approximately 1,500 miles with the engine installed in the vehicle. A single batch of No. 2 diesel fuel was used throughout the tests; a detailed fuel analysis is given in Table 2. Engine testing began on February 14, 1978 and ended on March 16, 1978.

During steady-state tests, the engine was operated at the following speed-load modes:

Speeds: 1,000; 1,650; 2,000; 2,500; 3,000; 3,500; 4,500; 5,000 rpm

Loads: 0, 10, 25, 40, 60, 75, 90, 100 pct of full load (0, 10, 25, 60, and 75 pct points were repeated at all engine speeds)

Idle speed-load modes: 800 rpm -- 0, 7, 14 lb-ft
700 rpm -- 31 lb-ft

Over speed point: 5,200 rpm -- 47 lb-ft (WOT)

Total number of test modes	69
Total number of repeats	94
Total number of motoring modes	6
Total number of tests	169

At the conclusion of the tests, the engine was motored at 1,000; 1,500; and 2,000 rpm. At each of the speeds the engine was motored with the fuel on and with the fuel off.

The following data were recorded for each test point:

Test number
Date
Barometric pressure, mm Hg
Wet bulb temperature, °F
Dry bulb temperature, °F
Speed, rpm

Torque, lb-ft -- BLH Strain gauge; Daytronic indicator
Fuel rate, lb/hr -- Fluidyne positive displacement fuel flow meter
Rack position (throttle angle), degrees
CO, pct -- Beckman NDIR
CO_2, pct -- Beckman NDIR
O_2, pct -- Beckman polarographic detector
HC, ppmC -- Custom built heated flame ionization detector
NO_x, ppm -- Thermo-Electron chemiluminescent detector
Oil temperature, °F
Oil pressure, psi
Coolant temperature, °F
Exhaust temperature, °F
Exhaust pressure, in. H_2O
Smoke, pct opacity -- Celesco smoke meter
Air flow, lb/min -- laminar flow element

The computed data include absolute humidity, power, exhaust flow rate, and emission rates of carbon monoxide (CO), unburned hydrocarbons (HC), and oxides of nitrogen (NO_x) in grams per hour. The following equations were applied in the computations:

1. Partial pressure of water vapor in intake air (millimeters of mercury)

$$P_v = \exp\left[18.717 - \frac{7308.1}{393 + T_w}\right] + \frac{P_b}{2784.2}\left[1 + \frac{T_w}{1533.2}\right]\left[T_w - T_D\right]$$

T_w = Wet bulb temperature, °F
T_D = Dry bulb temperature, °F
P_b = Barometric pressure, mm Hg

2. Humidity (grains moisture per pound dry air)

$$H = \frac{4347.3\ (P_v)}{P_b - P_v}$$

3. Corrected brake horsepower

$$HP_c = \left[\frac{(T)(N)}{5252.11}\right]\left\{\frac{\left[\frac{T_D + 460}{545}\right]^{0.7}}{\left[\frac{P_b - P_v}{736.6}\right]}\right\}$$

T = Brake torque (lb ft)
N = Engine speed (rpm)

4. Fuel mass flow rate (lbm/hr)

$$\dot{m}_f = \left(\dot{V}_f\right)\left(P_f\right)\left(\frac{3600}{453.59}\right)\left[1 + 0.0007(60 - T_F)\right]$$

$\dot{V}_f$ = Volume flow rate (cc/sec)
P_f = Fuel specific gravity
T_F = Fuel temperature (°F)

5. Convert hydrocarbon concentration measurements from wet basis to dry basis

$$HC_D = HC_W\left[1 + \frac{x}{200}\left(\frac{3CO_2[CO + CO_2]}{CO + 3CO_2}\right)\right]$$

HC_W = Hydrocarbon concentration on wet basis (pct)
x = Fuel hydrogen/carbon atomic ratio
CO_2 = Carbon dioxide concentration on dry basis (pct)
CO = Carbon monoxide concentration on dry basis (pct)

6. Carbon monoxide mass emission rate (grams/hour)

$$\dot{m}_{CO} = \left[\frac{453.59\left(\dot{m}_F\right)}{\left(M_F\right)(CO + CO_2 + HC_D)}\right](CO)\left(M_{CO}\right)$$

M_{CO} = Molecular weight of CO
M_F = Fuel molecular weight per carbon atom

7. Hydrocarbon mass emission rate (grams/hour)

$$\dot{m}_{HC} = \left[\frac{453.59\left(\dot{m}_F\right)}{\left(M_F\right)(CO + CO_2 + HC_D)}\right]\left(HC_D\right)\left(M_{HC}\right)$$

M_{HC} = Molecular weight of HC per carbon atom (assumed equal to M_F)

8. Oxides of nitrogen mass emission rate (grams/hour) (corrected for humidity)

$$\dot{m}_{NO_x} = \left[\frac{453.59\left(\dot{m}_F\right)}{M_F + (CO + CO_2 + HC_D)}\right]\left(NO_x\right)\left(M_{NO_2}\right)\left[\frac{1}{1 - 0.0025\ (H - 75)}\right]$$

M_{NO_2} = Molecular weight of NO_2

NO_x = Oxides of nitrogen concentration on dry basis (pct)

3. DISCUSSION OF TEST RESULTS

Maximum corrected brake horsepower, maximum corrected torque, and brake specific fuel consumption (bsfc) are plotted as a function of engine speed at full rack position in Figure 1. The maximum power output of the engine was produced at the specified speed and was similar to the value quoted in Table 1. The maximum torque produced by the engine was similar to the value quoted in Table 1 but was produced at a higher speed. The fuel rates were found to be nearly a linear function of power for all engine speeds and were repeatable for each speed.

Fuel rates were found to be nearly a linear function of power for most engine speeds (Figure 2).

Emissions of carbon nomoxide (CO), hydrocarbon (HC), and oxides of nitrogen (NO_x) are plotted as a function of power for all engine speeds (Figures 3, 4, 5). The emissions of CO, HC, and NO_x were reasonably repeatable for all engine speeds. At particular speeds (1,000; 2,000; 2,500; 3,000 rpm), during light load and no load operation, some scatter in teh CO and HC emissions was observed. The scatter at these modes is typical for light load operation. Exhaust stream opacity showed low levels of smoke for all engine speeds (Figure 6). The maximum opacity observed was 10 percent at 5,000 rpm (WOT).

4. CONCLUSIONS

The experimental work to obtain performance data for the Volkswagen 90 CID diesel engine has been completed, and these data are presented in the tables accompanying this report.

TABLE 1. - MANUFACTURER'S ENGINE SPECIFICATIONS

Displacement, cubic inches	90
Maximum horsepower, bhp @ 5,000 rpm	48
Maximum torque, lb-ft @ 2,500 rpm	58
Bore and stroke, inches	3.012 x 3.15
Compression ratio	23:1
Configuration	in-line, 4-cyl.
Firing order	1-3-4-2
Block material	cast iron
Head material	cast aluminum
Number of crankshaft main bearings	5
Number of compression rings/piston	2
Number of oil rings/piston	1
Cam drive type	belt
Valve lift:	
Intake, inches	0.32
Exhaust, inches	0.35
Valve timing:	
Intake opens, °BTC	5
Intake closes, °ABC	14
Exhaust opens, °BBC	27
Exhaust closes, °ATC	5
Engine weight, lbs	305
Carburetor type	fuel injection
Injection pressure, psi	1,778
Injection timing, inch stroke @ TDC	0.033
Fuel pump type	Bosch mechanical injection pump
Combustion system	swirl chamber

TABLE 2. - FUEL ANALYSIS

Fuel No. (No. 2 diesel)	7807
Distillation, °F:	
10 pct evaporated	396
50 pct "	478
95 pct "	596
End point "	614
API gravity, degrees	36.55
Specific gravity, degrees	0.842
FIA analysis, pct:	
Aromatics	27
Olefins	3
Paraffins	70
Sulfur, pct	0.218
Hydrogen/carbon atomic ratio	1.79

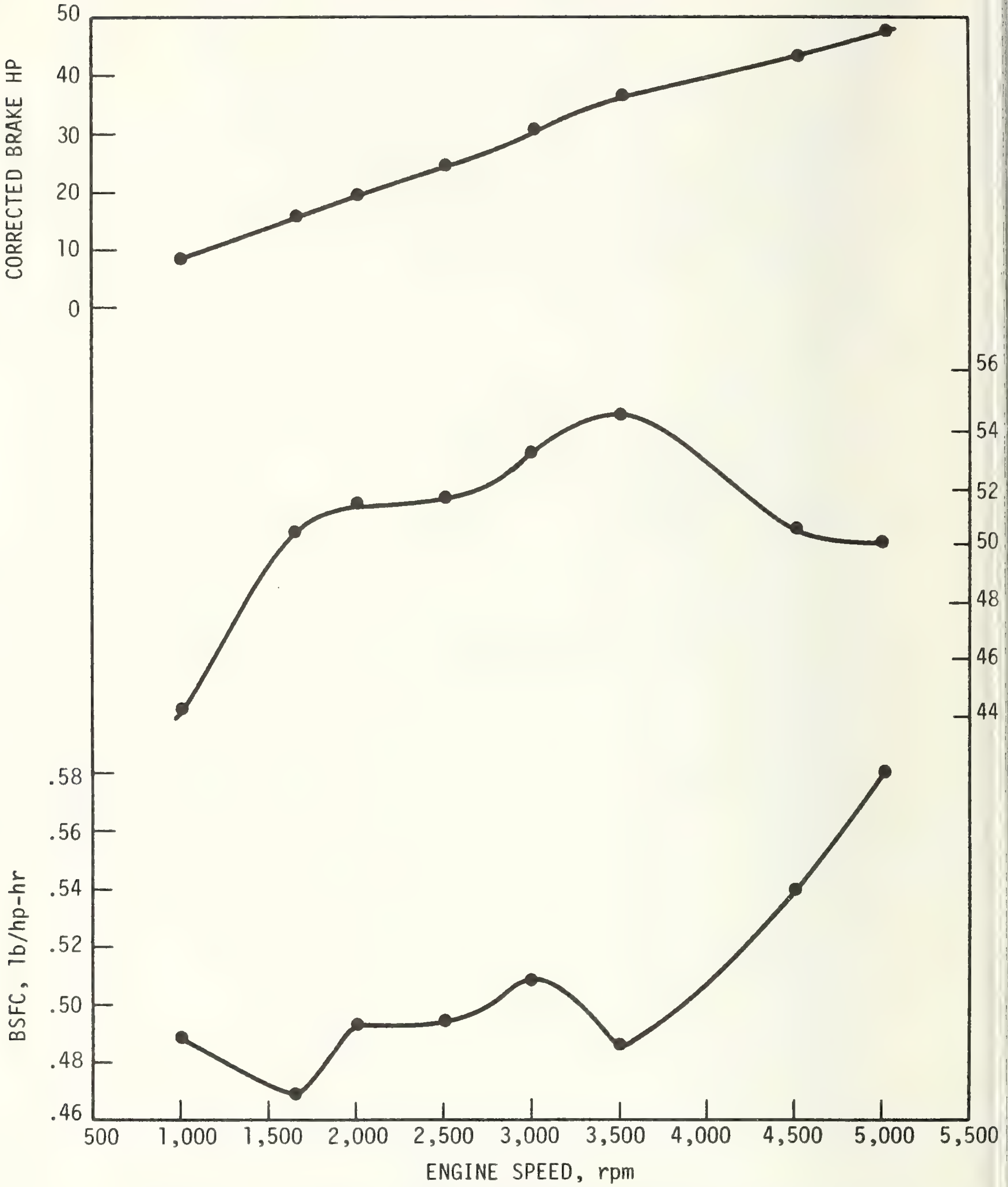


FIGURE 1. Brake Specific Fuel Consumption, Torque, and Brake Horsepower Versus Engine rpm at Wide-Open-Throttle--Volkswagen 90-CID Diesel Engine.

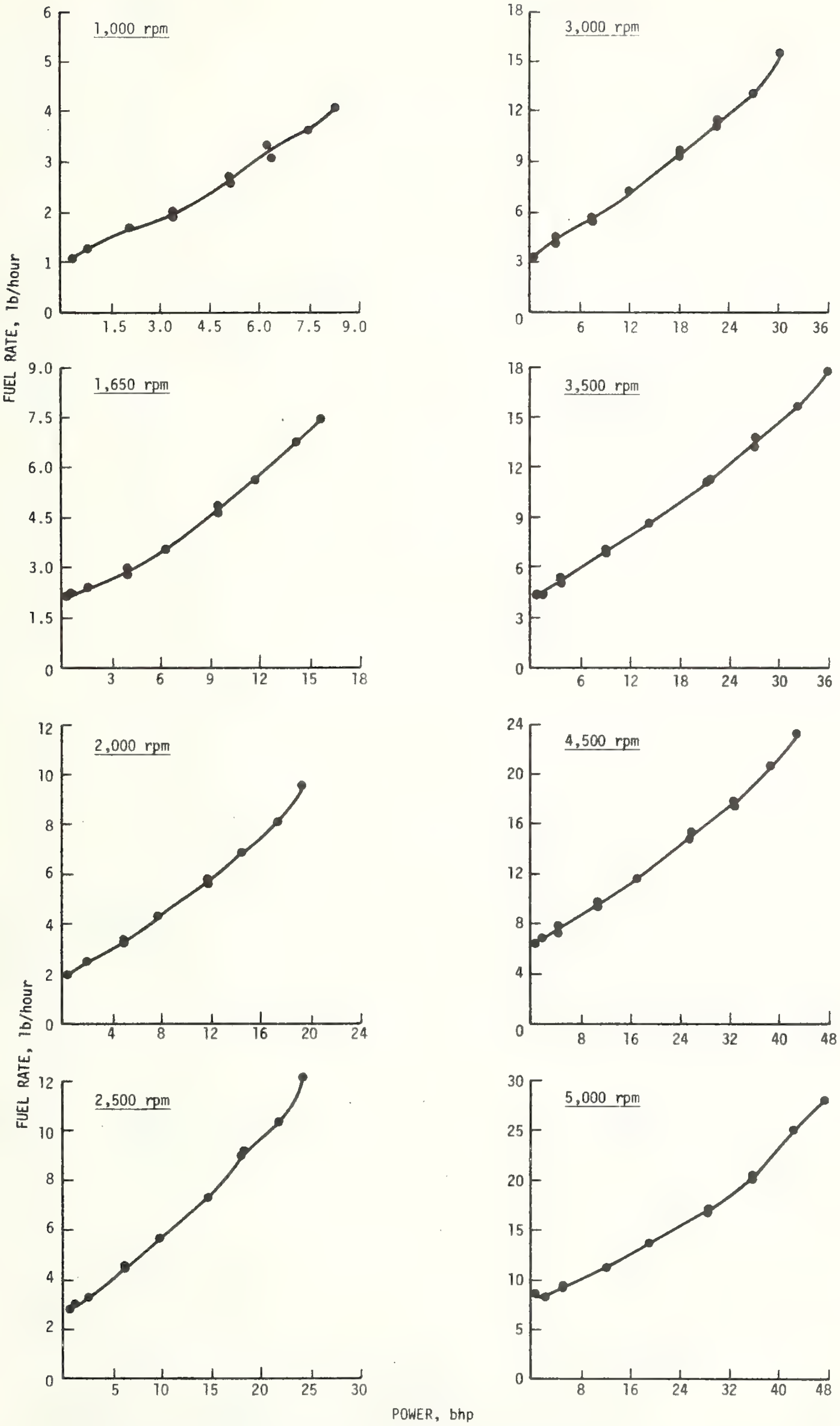


FIGURE 2. Fuel Rate Versus Power at Various Speed and Load Conditions--Volkswagen 90 CID Diesel Engine.

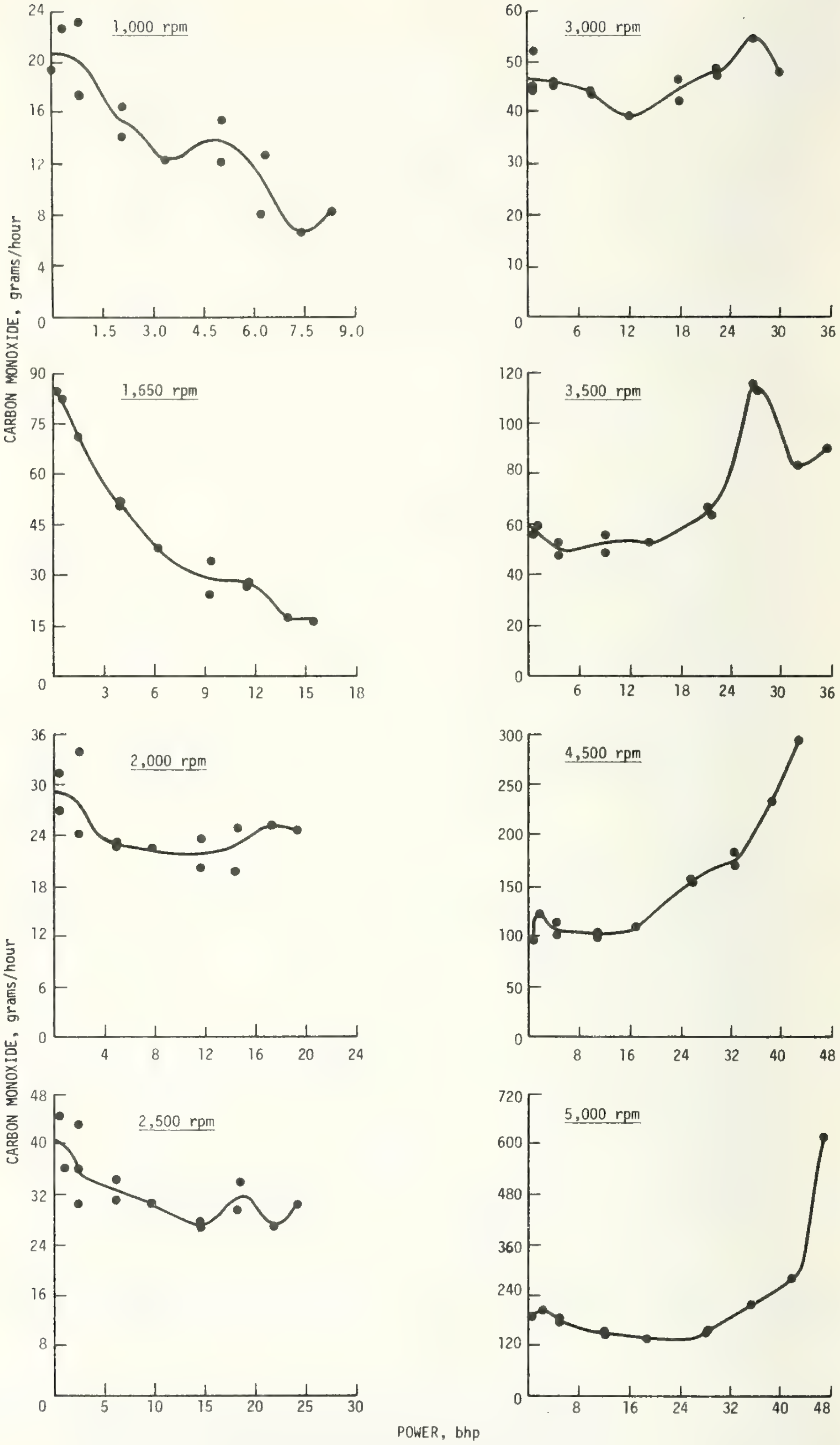


FIGURE 3. Carbon Monoxide Emissions Versus Power at Various Speed and Load Conditions--Volkswagen 90 CID Diesel Engine.

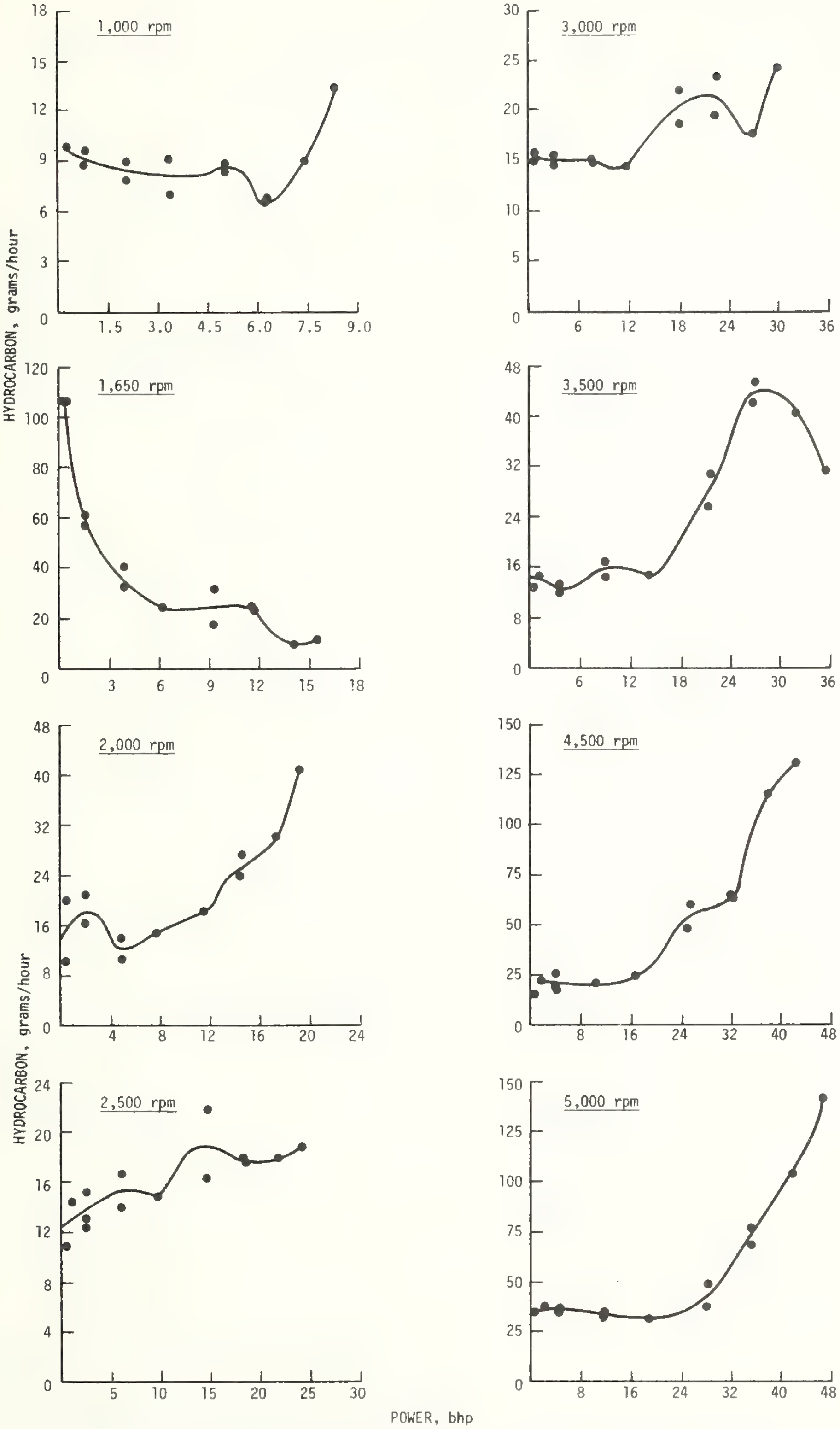


FIGURE 4. Hydrocarbon Emissions Versus Power at Various Speed and Load Conditions--Volkswagen 90 CID Diesel Engine.

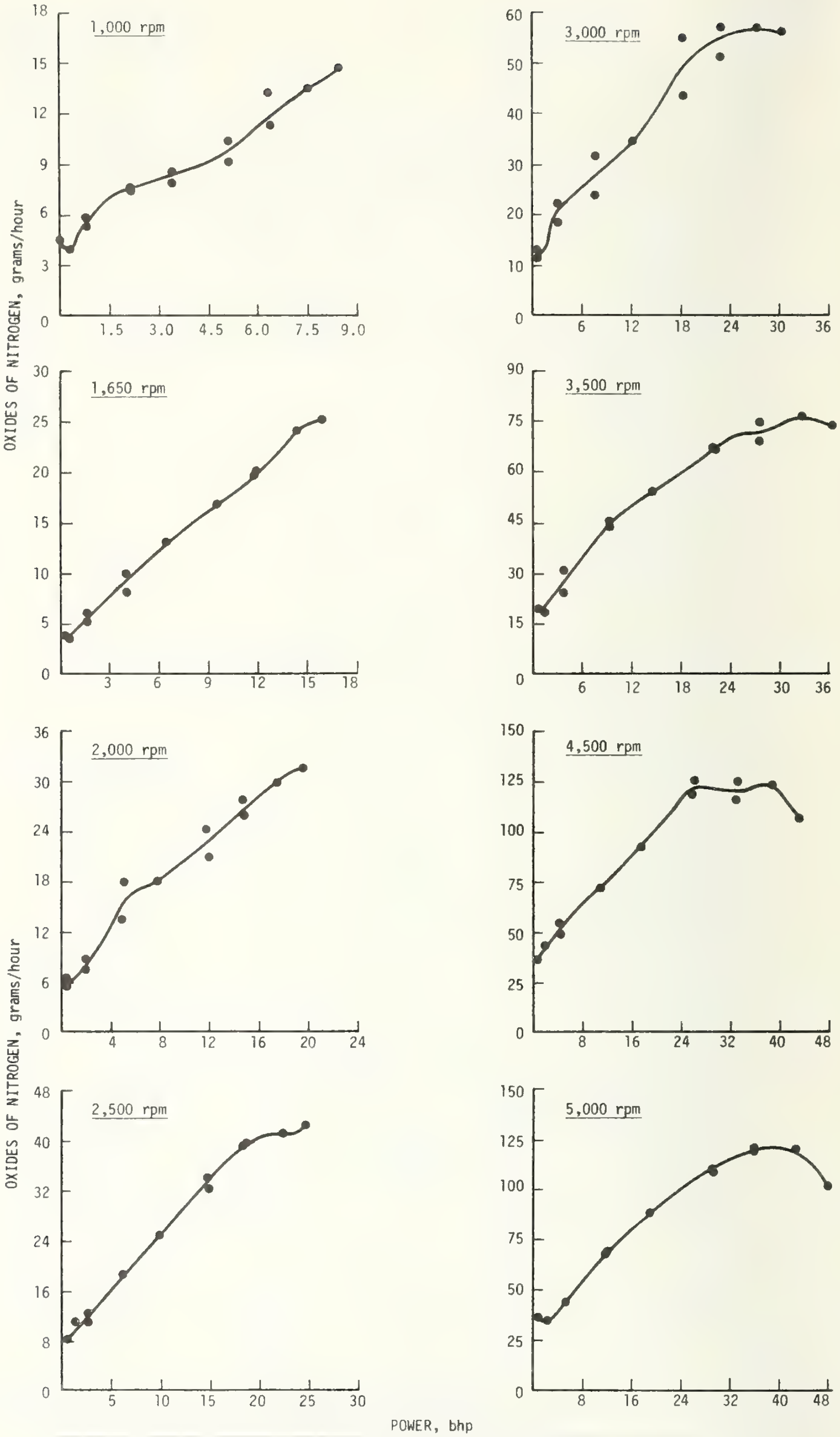


FIGURE 5. Oxides of Nitrogen Emissions Versus Power at Various Speed and Load Conditions--Volkswagen 90 CID Diesel Engine.

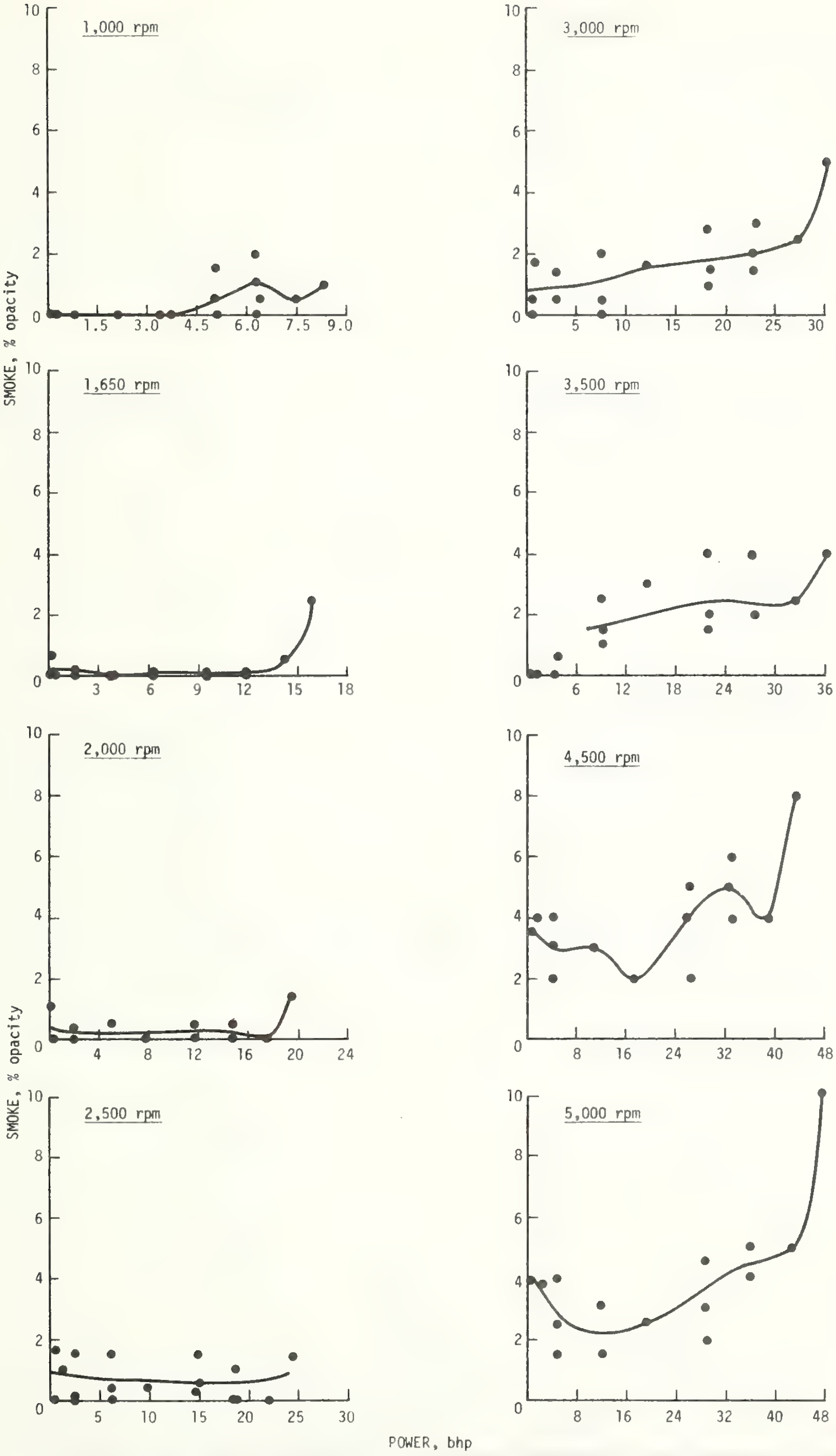


FIGURE 6. Smoke Versus Power at Various Speed and Load Conditions--Volkswagen 90 CID Diesel Engine.

ENGINE: 1978 VW 90-CID DIESEL
FUEL CODE: 7807

TEST NUMBER	1.01	2.01	3.01	4.01	5.01	6.01
DATA SOURCE CODE	1	1	1	1	1	1
TEST DATE	2/14/78	2/14/78	2/14/78	2/14/78	2/14/78	2/14/78
BAROMETER, MMHG	749.0	749.0	749.0	749.0	749.5	749.5
HUMIDITY, GRAINS/LB	33	33	33	33	33	33
TEMPERATURE, F	73	73	73	72	72	73
ENGINE SPEED, RPM	825	820	800	700	1000	1000
TORQUE, FT-LB	3.4	6.5	13.0	30.6	45.1	40.6
POWER, BHP*	.5	1.0	1.9	4.0	8.4	7.5
FUEL RATE, LB/HR	1.2	1.2	1.5	2.5	4.1	3.6
THROTTLE ANGLE, DEG	.0	.2	.2	1.1	39.5	12.6
CONCENTRATIONS, DRY BASIS						
CO, %	.0499	.0503	.0444	.0343	.0202	.0170
CO2, %	2.66	2.95	3.91	8.03	9.16	8.49
O2, %	17.12	16.63	15.34	9.69	7.62	9.04
HC, PPMC	730	854	1247	605	661	473
NOX, PPM	89	91	99	132	241	235
SMOKE, % OPACITY	1.0	2.5	5.0	2.0	1.0	.5
EMISSION RATES, G/HR						
CO	19.9	17.9	15.3	9.6	8.3	6.6
HC	14.4	14.9	21.1	8.3	13.4	9.0
NOX+	5.3	4.8	5.1	5.5	14.7	13.5
OIL TEMPERATURE, F	155	159	163	139	177	184
OIL PRESSURE, PSI	39	37	33	47	40	35
COOLANT TEMPERATURE, F	161	167	173	145	182	181
EXHAUST PRESSURE, IN. H2O	2.0	2.0	2.0	2.0	2.0	2.0
EXHAUST TEMPERATURE, F	206	220	272	386	590	575
EXHAUST FLOW RATE, LB/HR	77.6	77.5	74.0	75.0	88.2	86.4

* CORRECTED SAE J816B
+ CORRECTED FOR HUMIDITY

ENGINE: 1978 VW 90-CID DIESEL
FUEL CODE: 7807

TEST NUMBER	7.01	10.01	11.01	12.01	13.01	14.01
DATA SOURCE CODE	1	1	1	1	1	1
TEST DATE	2/14/78	2/16/78	2/16/78	3/16/78	2/16/78	2/16/78
BAROMETER, MMHG	749.5	750.0	750.0	750.0	749.6	749.6
HUMIDITY, GRAINS/LB	33	35	35	35	40	40
TEMPERATURE, F	73	74	75	75	74	75
ENGINE SPEED, RPM	1000	1000	1000	1000	1650	1650
TORQUE, FT-LB	33.8	11.3	4.5	1.5	51.5	46.4
POWER, BHP*	6.3	2.1	.8	.3	15.8	14.3
FUEL RATE, LB/HR	3.3	1.7	1.3	1.1	7.4	6.7
THROTTLE ANGLE, DEG	10.8	7.5	6.6	5.6	38.0	20.7
CONCENTRATIONS, DRY BASIS						
CO, %	.0192	.0346	.0409	.0540	.0244	.0252
CO2, %	7.06	3.63	2.69	2.22	10.15	8.92
O2, %	11.05	16.33	17.58	18.26	7.05	8.78
HC, PPMC	317	445	417	471	324	273
NOX, PPM	210	124	91	62	248	233
SMOKE, % OPACITY	.0	.0	.0	.0	2.5	.5
EMISSION RATES, G/HR						
CO	8.1	14.2	17.5	22.8	16.3	17.2
HC	6.6	9.0	8.8	9.8	10.7	9.2
NOX+	13.2	7.6	5.8	3.9	25.1	24.1
OIL TEMPERATURE, F	185	168	172	173	185	205
OIL PRESSURE, PSI	33	44	39	40	59	46
COOLANT TEMPERATURE, F	180	167	173	172	177	182
EXHAUST PRESSURE, IN. H2O	2.0	2.0	2.0	2.0	11.0	13.0
EXHAUST TEMPERATURE, F	500	267	234	207	780	760
EXHAUST FLOW RATE, LB/HR	87.3	95.6	93.9	100.0	248.9	156.9

* CORRECTED SAE J816B
+ CORRECTED FOR HUMIDITY

ENGINE: 1978 VW 90-CID DIESEL
FUEL CODE: 7807

TEST NUMBER	16.01	17.01	18.01	19.01	20.01	21.01
DATA SOURCE CODE	1	1	1	1	1	1
TEST DATE	2/16/78	2/16/78	2/16/78	2/16/78	2/16/78	2/16/78
BAROMETER, MMHG	749.5	749.5	749.5	749.5	749.5	749.5
HUMIDITY, GRAINS/LB	41	41	41	41	41	33
TEMPERATURE, F	72	72	72	73	72	76
ENGINE SPEED, RPM	1650	1650	1650	1650	1650	2000
TORQUE, FT-LB	30.9	20.6	12.9	5.2	.6	52.6
POWER, BHP*	9.5	6.3	4.0	1.6	.2	19.5
FUEL RATE, LB/HR	4.6	3.5	2.8	2.4	2.1	9.6
THROTTLE ANGLE, DEG	17.0	15.0	14.1	13.2	13.0	39.4
CONCENTRATIONS, DRY BASIS						
CO, %	.0348	.0528	.0707	.0987	.1130	.0297
CO2, %	6.03	4.39	3.50	2.77	2.13	10.59
O2, %	12.83	15.09	16.24	16.52	17.27	6.03
HC, PPMC	490	665	913	1600	2873	994
NOX, PPM	158	119	92	57	33	257
SMOKE, % OPACITY	.2	.0	.0	.2	.6	1.4
EMISSION RATES, G/HR						
CO	24.2	37.9	50.1	70.7	84.5	24.5
HC	16.9	23.6	31.9	56.5	105.9	40.5
NOX+	16.7	12.9	9.9	6.1	3.7	31.6
OIL TEMPERATURE, F	181	193	193	190	187	203
OIL PRESSURE, PSI	61	53	54	56	59	59
COOLANT TEMPERATURE, F	183	178	176	175	174	183
EXHAUST PRESSURE, IN. H2O	5.0	5.0	4.0	4.0	3.0	12.0
EXHAUST TEMPERATURE, F	517	408	350	301	259	917
EXHAUST FLOW RATE, LB/HR	155.2	156.4	158.1	157.7	159.7	195.4

* CORRECTED SAE J816B
+ CORRECTED FOR HUMIDITY

ENGINE: 1978 VW 90-CID DIESEL
FUEL CODE: 7807

TEST NUMBER	22.01	23.01	24.01	25.01	26.01	27.01
DATA SOURCE CODE	1	1	1	1	1	1
TEST DATE	2/16/78	2/16/78	2/16/78	3/16/78	2/16/78	2/16/78
BAROMETER, MMHG	749.5	749.5	749.5	749.5	749.5	749.5
HUMIDITY, GRAINS/LB	33	33	29	29	33	29
TEMPERATURE, F	75	75	75	75	74	74
ENGINE SPEED, RPM	2000	2000	2000	2000	2000	2000
TORQUE, FT-LB	47.3	39.5	31.6	21.0	13.2	5.3
POWER, BHP*	17.5	14.6	11.7	7.8	4.9	2.0
FUEL RATE, LB/HR	8.1	6.9	5.8	4.3	3.4	2.5
THROTTLE ANGLE, DEG	21.1	19.9	18.1	16.1	14.8	13.6
CONCENTRATIONS, DRY BASIS						
CO, %	.0302	.0240	.0239	.0269	.0265	.0373
CO2, %	8.78	7.64	6.27	4.74	3.61	2.50
O2, %	8.00	9.91	11.74	13.82	15.23	16.48
HC, PPMC	724	578	434	354	325	365
NOX, PPM	241	228	196	147	106	55
SMOKE, % OPACITY	.0	.0	.0	.0	.5	.4
EMISSION RATES, G/HR						
CO	25.2	19.8	20.1	22.4	22.6	33.9
HC	29.9	23.6	18.0	14.5	13.7	16.4
NOX+	30.0	27.9	24.4	18.1	13.5	7.4
OIL TEMPERATURE, F	208	210	208	205	202	199
OIL PRESSURE, PSI	55	54	57	59	61	63
COOLANT TEMPERATURE, F	184	182	180	178	178	176
EXHAUST PRESSURE, IN. H2O	10.0	9.0	9.0	8.0	7.0	6.0
EXHAUST TEMPERATURE, F	787	707	598	463	391	306
EXHAUST FLOW RATE, LB/HR	189.2	189.2	192.6	191.1	193.8	192.8

* CORRECTED SAE J816B
+ CORRECTED FOR HUMIDITY

ENGINE: 1978 VW 90-CID DIESEL
FUEL CODE: 7807

TEST NUMBER	29.01	30.01	31.01	32.01	33.01	34.01
DATA SOURCE CODE	1	1	1	1	1	1
TEST DATE	2/16/78	2/16/78	2/16/78	2/16/78	2/16/78	2/16/78
BAROMETER, MMHG	749.5	749.5	749.5	749.5	749.5	749.5
HUMIDITY, GRAINS/LB	35	35	35	35	35	35
TEMPERATURE, F	77	76	76	76	75	75
ENGINE SPEED, RPM	2500	2500	2500	2500	2500	2500
TORQUE, FT-LB	52.8	47.5	39.6	31.7	21.1	13.2
POWER, BHP*	24.5	22.1	18.4	14.7	9.8	6.1
FUEL RATE, LB/HR	12.1	10.3	9.0	7.2	5.6	4.5
THROTTLE ANGLE, DEG	39.5	22.4	20.5	19.0	16.8	15.5
CONCENTRATIONS, DRY BASIS						
CO, %	.0288	.0254	.0271	.0253	.0284	.0285
CO2, %	10.58	8.96	7.61	6.31	4.72	3.73
O2, %	6.33	8.47	10.21	12.18	14.26	15.50
HC, PPMC	367	348	337	315	281	260
NOX, PPM	271	259	242	206	153	112
SMOKE, % OPACITY	1.4	.0	.0	.2	.4	.4
EMISSION RATES, G/HR						
CO	30.1	26.7	29.3	26.5	30.6	31.3
HC	18.9	18.0	18.0	16.3	14.9	14.0
NOX+	42.3	40.7	39.2	32.3	24.6	18.3
OIL TEMPERATURE, F	217	219	220	218	215	211
OIL PRESSURE, PSI	64	63	64	66	60	71
COOLANT TEMPERATURE, F	185	185	183	181	180	178
EXHAUST PRESSURE, IN. H2O	16.0	14.0	13.0	12.0	11.0	11.0
EXHAUST TEMPERATURE, F	996	857	758	640	508	411
EXHAUST FLOW RATE, LB/HR	246.5	245.7	246.6	245.9	246.5	249.7

* CORRECTED SAE J816B
+ CORRECTED FOR HUMIDITY

ENGINE: 1978 VW 90-CID DIESEL
FUEL CODE: 7807

TEST NUMBER	35.01	36.01	37.01	38.01	39.01	40.01
DATA SOURCE CODE	1	1	1	1	1	1
TEST DATE	2/16/78	2/17/78	2/17/78	2/17/78	2/17/78	2/17/78
BAROMETER, MMHG	749.5	750.8	750.8	750.8	750.8	750.8
HUMIDITY, GRAINS/LB	35	32	32	32	32	32
TEMPERATURE, F	75	73	75	75	76	75
ENGINE SPEED, RPM	2500	2500	3000	3000	3000	3000
TORQUE, FT-LB	5.3	1.0	54.5	49.1	40.9	32.7
POWER, BHP*	2.5	.5	30.3	27.3	22.7	18.2
FUEL RATE, LB/HR	3.2	2.8	15.4	13.0	11.0	9.2
THROTTLE ANGLE, DEG	13.4	12.2	39.5	24.3	22.6	21.0
CONCENTRATIONS, DRY BASIS						
CO, %	.0286	.0375	.0360	.0402	.0362	.0311
CO2, %	2.74	2.12	10.57	8.79	7.42	6.19
O2, %	16.88	18.03	6.01	8.28	10.61	12.09
HC, PPMC	235	187	369	263	291	277
NOX, PPM	69	47	285	284	256	216
SMOKE, % OPACITY	.2	1.6	5.0	2.5	2.0	2.8
EMISSION RATES, G/HR						
CO	30.6	44.4	47.9	54.3	48.9	42.2
HC	12.4	10.9	24.2	17.5	19.4	18.6
NOX+	11.1	8.2	56.3	57.0	51.3	43.5
OIL TEMPERATURE, F	209	202	229	227	229	226
OIL PRESSURE, PSI	73	79	69	72	72	75
COOLANT TEMPERATURE, F	178	181	187	185	184	183
EXHAUST PRESSURE, IN. H2O	10.0	9.0	25.0	23.0	21.0	19.0
EXHAUST TEMPERATURE, F	334	275	1089	920	785	670
EXHAUST FLOW RATE, LB/HR	250.6	253.5	301.9	303.5	304.6	305.9

* CORRECTED SAE J816B
+ CORRECTED FOR HUMIDITY

ENGINE: 1978 VW 90-CID DIESEL
FUEL CODE: 7807

TEST NUMBER	41.01	42.01	44.01	45.01	46.01	47.01
DATA SOURCE CODE	1	1	1	1	1	1
TEST DATE	2/17/78	2/17/78	2/17/78	2/17/78	2/17/78	2/17/78
BAROMETER, MMHG	752.8	752.8	751.5	751.5	752.8	751.5
HUMIDITY, GRAINS/LB	32	32	32	32	32	32
TEMPERATURE, F	74	74	73	74	75	75
ENGINE SPEED, RPM	3000	3000	3000	3500	3500	3500
TORQUE, FT-LB	21.8	13.6	1.5	56.0	50.4	42.0
POWER BHP*	12.1	7.5	.8	36.2	32.6	27.2
FUEL RATE, LB/HR	7.2	5.7	3.4	17.6	15.5	13.2
THROTTLE ANGLE, DEG	18.3	16.5	13.0	39.5	27.5	25.2
CONCENTRATIONS, DRY BASIS						
CO, %	.0278	.0315	.0348	.0600	.0549	.0749
CO2, %	4.66	3.72	2.36	10.67	9.23	7.79
O2, %	14.88	15.93	18.02	6.33	8.35	10.54
HC, PPMC	204	219	151	424	541	557
NOX, PPM	164	115	59	330	337	303
SMOKE, % OPACITY	1.6	2.0	1.7	4.0	2.5	4.0
EMISSION RATES, G/HR						
CO	39.2	44.1	45.2	90.3	83.7	114.9
HC	14.2	15.1	9.7	31.4	40.6	42.2
NOX+	34.4	23.9	11.4	73.9	76.2	69.1
OIL TEMPERATURE, F	221	219	202	237	235	233
OIL PRESSURE, PSI	78	81	89	79	79	82
COOLANT TEMPERATURE, F	184	182	173	185	185	184
EXHAUST PRESSURE, IN. H2O	19.0	16.0	14.0	32.0	32.0	30.0
EXHAUST TEMPERATURE, F	528	430	290	900	880	790
EXHAUST FLOW RATE, LB/HR	312.7	310.3	311.4	362.6	362.9	360.1

* CORRECTED SAE J816B
+ CORRECTED FOR HUMIDITY

ENGINE: 1978 VW 90-CID DIESEL
FUEL CODE: 7807

TEST NUMBER	48.01	49.01	51.01	52.01	53.01	54.01
DATA SOURCE CODE	1	1	1	1	1	1
TEST DATE	2/17/78	2/17/78	2/17/78	2/17/78	2/17/78	2/17/78
BAROMETER, MMHG	751.5	751.5	752.8	752.8	752.8	752.8
HUMIDITY, GRAINS/LB	32	32	32	32	32	32
TEMPERATURE, F	75	74	75	76	80	77
ENGINE SPEED, RPM	3500	3500	3500	3500	4500	4500
TORQUE, FT-LB	33.6	22.4	5.6	2.2	52.0	46.8
POWER, BHP*	21.7	14.5	3.6	1.4	43.2	38.9
FUEL RATE, LB/HR	11.1	8.6	5.1	4.3	23.3	20.7
THROTTLE ANGLE, DEG	22.5	19.4	14.6	13.3	39.6	28.1
CONCENTRATIONS, DRY BASIS						
CO, %	.0425	.0341	.0343	.0390	.1618	.1220
CO2, %	6.39	5.01	2.99	2.56	11.52	9.75
O2, %	12.44	14.45	16.79	17.33	5.38	7.96
HC, PPMC	329	191	177	193	1471	1238
NOX, PPM	287	233	105	82	400	434
SMOKE, % OPACITY	4.0	3.0	.0	.0	8.0	4.0
EMISSION RATES, G/HR						
CO	67.0	53.4	52.6	59.3	293.3	232.2
HC	25.6	14.7	13.4	14.4	131.5	116.3
NOX+	67.2	54.0	24.0	18.5	107.7	122.8
OIL TEMPERATURE, F	237	234	198	219	262	260
OIL PRESSURE, PSI	80	83	95	88	78	80
COOLANT TEMPERATURE, F	183	181	170	181	188	186
EXHAUST PRESSURE, IN. H2O	28.0	25.0	18.0	18.0	60.0	53.0
EXHAUST TEMPERATURE, F	675	540	349	333	1215	1035
EXHAUST FLOW RATE, LB/HR	359.8	363.0	364.7	364.9	452.7	453.3

* CORRECTED SAE J816B
+ CORRECTED FOR HUMIDITY

ENGINE: 1978 VW 90-CID DIESEL
FUEL CODE: 7807

TEST NUMBER	56.01	57.01	58.01	59.01	60.01	61.01
DATA SOURCE CODE	1	1	1	1	1	1
TEST DATE	2/17/78	2/17/78	2/17/78	2/17/78	2/17/78	2/21/78
BAROMETER, MMHG	752.8	752.8	752.8	752.8	752.8	745.0
HUMIDITY, GRAINS/LB	32	32	32	32	32	31
TEMPERATURE, F	76	75	74	74	74	77
ENGINE SPEED, RPM	4500	4500	4500	4500	4500	5000
TORQUE, FT-LB	31.0	20.8	13.0	5.2	2.2	51.0
POWER BHP*	25.7	17.3	10.8	4.3	1.8	47.6
FUEL RATE, LB/HR	14.8	11.6	9.4	7.3	6.9	27.6
THROTTLE ANGLE, DEG	22.3	18.6	15.7	13.6	12.6	39.4
CONCENTRATIONS, DRY BASIS						
CO, %	.0820	.0566	.0500	.0520	.0592	.3212
CO2, %	6.95	5.48	4.43	3.38	3.05	12.88
O2, %	11.53	13.71	15.17	16.57	16.99	3.27
HC, PPMC	509	256	217	204	219	1505
NOX, PPM	415	323	250	171	144	360
SMOKE, % OPACITY	4.0	2.0	3.0	3.0	4.0	10.0
EMISSION RATES, G/HR						
CO	157.3	108.5	96.0	100.9	119.2	610.0
HC	48.2	24.2	20.5	19.6	21.7	141.0
NOX+	118.4	91.9	71.5	49.4	43.0	101.2
OIL TEMPERATURE, F	257	254	251	249	246	264
OIL PRESSURE, PSI	82	84	85	86	87	82
COOLANT TEMPERATURE, F	183	182	183	181	181	187
EXHAUST PRESSURE, IN. H2O	45.0	40.0	37.0	34.0	33.0	69.0
EXHAUST TEMPERATURE, F	740	601	506	436	416	1337
EXHAUST FLOW RATE, LB/HR	450.7	449.1	450.1	449.6	449.9	470.8

* CORRECTED SAE J816B
+ CORRECTED FOR HUMIDITY

ENGINE: 1978 VW 90-CID DIESEL
FUEL CODE: 7807

TEST NUMBER	62.01	63.01	64.01	65.01	66.01	67.01
DATA SOURCE CODE	1	1	1	1	1	1
TEST DATE	2/21/78	2/21/78	2/21/78	2/21/78	2/21/78	2/21/78
BAROMETER, MMHG	749.8	745.0	745.0	745.0	745.0	745.0
HUMIDITY, GRAINS/LB	31	31	31	31	31	31
TEMPERATURE, F	76	76	76	76	75	75
ENGINE SPEED, RPM	5000	5000	5000	5000	5000	5000
TORQUE, FT-LB	45.9	38.3	30.6	20.4	12.8	5.1
POWER, BHP*	42.6	35.8	28.6	19.0	11.9	4.8
FUEL RATE, LB/HR	24.7	19.9	16.6	13.6	11.2	9.2
THROTTLE ANGLE, DEG	.0	.0	.0	.0	.0	.0
CONCENTRATIONS, DRY BASIS						
CO, %	.1388	.1057	.0737	.0672	.0764	.0898
CO2, %	11.10	8.88	7.56	6.08	4.95	3.97
O2, %	5.65	8.55	10.40	12.38	13.84	15.07
HC, PPMC	1048	765	378	313	323	362
NOX, PPM	401	400	373	298	228	143
SMOKE, % OPACITY	5.0	4.0	3.0	2.5	3.0	4.0
EMISSION RATES, G/HR						
CO	278.2	213.3	146.8	135.9	155.3	185.2
HC	103.5	76.1	37.1	31.2	32.3	36.8
NOX+	119.0	119.6	110.0	89.3	68.7	43.7
OIL TEMPERATURE, F	252	262	265	260	256	255
OIL PRESSURE, PSI	86	83	83	85	85	87
COOLANT TEMPERATURE, F	188	185	183	182	181	180
EXHAUST PRESSURE, IN. H2O	61.0	53.0	50.0	46.0	43.0	40.0
EXHAUST TEMPERATURE, F	1143	936	820	685	597	515
EXHAUST FLOW RATE, LB/HR	474.7	467.0	465.2	466.0	466.6	465.3

* CORRECTED SAE J816B
+ CORRECTED FOR HUMIDITY

ENGINE: 1978 VW 90-CID DIESEL
FUEL CODE: 7807

TEST NUMBER	68.01	69.01	70.01	71.01	72.01	74.01
DATA SOURCE CODE	1	1	1	1	1	1
TEST DATE	2/21/78	2/21/78	2/21/78	2/21/78	2/21/78	2/21/78
BAROMETER, MMHG	745.0	745.0	745.0	745.0	745.0	745.0
HUMIDITY, GRAINS/LB	31	33	33	33	33	33
TEMPERATURE, F	75	75	74	74	74	74
ENGINE SPEED, RPM	5000	800	800	800	700	1000
TORQUE, FT-LB	2.5	1.8	6.5	13.0	22.0	27.1
POWER, BHP*	2.3	.3	1.0	1.9	2.9	5.1
FUEL RATE, LB/HR	8.5	1.0	1.2	1.5	2.1	2.6
THROTTLE ANGLE, DEG	.0	.0	.2	1.7	.0	10.7
CONCENTRATIONS, DRY BASIS						
CO, %	.0974	.0507	.0466	.0409	.0340	.0306
CO2, %	3.64	2.54	3.13	4.05	6.84	5.93
O2, %	15.43	17.66	16.71	15.43	11.62	12.83
HC, PPMC	367	387	436	450	448	424
NOX, PPM	115	88	111	134	134	175
SMOKE, % OPACITY	3.8	.0	.0	.5	2.0	1.5
EMISSION RATES, G/HR						
CO	202.0	18.0	15.8	13.9	9.4	12.3
HC	37.5	6.8	7.3	7.5	6.1	8.4
NOX+	35.4	4.6	5.6	6.8	5.5	10.4
OIL TEMPERATURE, F	254	176	168	166	165	175
OIL PRESSURE, PSI	87	29	32	33	28	37
COOLANT TEMPERATURE, F	180	168	166	167	170	178
EXHAUST PRESSURE, IN. H2O	39.0	.0	.0	.0	.0	1.0
EXHAUST TEMPERATURE, F	501	208	210	236	303	326
EXHAUST FLOW RATE, LB/HR	466.2	74.4	73.3	72.4	60.1	93.7

* CORRECTED SAE J816B
+ CORRECTED FOR HUMIDITY

ENGINE: 1978 VW 90-CID DIESEL
FUEL CODE: 7807

TEST NUMBER	75.01	76.01	78.01	79.01	80.01	81.01
DATA SOURCE CODE	1	1	1	1	1	1
TEST DATE	2/21/78	2/21/78	2/21/78	2/21/78	2/21/78	2/21/78
BAROMETER, MMHG	745.0	745.0	745.0	745.0	745.0	745.0
HUMIDITY, GRAINS/LB	33	33	33	33	33	31
TEMPERATURE, F	74	74	74	74	74	74
ENGINE SPEED, RPM	1000	1000	1650	1650	1650	1650
TORQUE, FT-LB	11.3	4.5	38.6	30.9	12.9	5.2
POWER, BHP*	2.1	.8	11.9	9.5	4.0	1.6
FUEL RATE, LB/HR	1.7	1.3	5.6	4.8	3.0	2.4
THROTTLE ANGLE, DEG	7.5	5.7	38.6	16.4	13.6	12.8
CONCENTRATIONS, DRY BASIS						
CO, %	.0393	.0519	.0406	.0463	.0683	.0912
CO2, %	3.51	2.53	7.31	5.87	3.37	2.60
O2, %	15.91	17.09	10.75	12.62	15.74	16.64
HC, PPMC	377	437	665	857	1049	1587
NOX, PPM	118	79	193	154	72	44
SMOKE, % OPACITY	.0	.0	.1	.0	.0	.0
EMISSION RATES, G/HR						
CO	16.6	23.2	28.3	34.0	52.4	71.1
HC	7.9	9.6	22.9	31.1	39.7	61.1
NOX+	7.4	5.3	20.0	16.8	8.2	5.1
OIL TEMPERATURE, F	177	171	183	188	187	186
OIL PRESSURE, PSI	37	40	56	55	58	59
COOLANT TEMPERATURE, F	175	168	182	179	175	173
EXHAUST PRESSURE, IN. H2O	.0	.0	4.0	4.0	4.0	3.0
EXHAUST TEMPERATURE, F	266	195	634	519	355	305
EXHAUST FLOW RATE, LB/HR	96.5	94.9	154.1	156.8	158.5	159.8

* CORRECTED SAE J816B
+ CORRECTED FOR HUMIDITY

ENGINE: 1978 VW 90-CID DIESEL
FUEL CODE: 7807

TEST NUMBER	82.01	86.01	87.01	89.01	90.01	91.01
DATA SOURCE CODE	1	1	1	1	1	1
TEST DATE	2/21/78	2/22/78	2/22/78	2/22/78	2/22/78	2/22/78
BAROMETER, MMHG	745.0	745.5	745.5	745.5	745.5	745.5
HUMIDITY, GRAINS/LB	31	35	35	35	35	39
TEMPERATURE, F	74	76	76	77	76	76
ENGINE SPEED, RPM	1650	2000	2000	2500	2500	2500
TORQUE, FT-LB	1.6	5.3	1.1	31.7	13.2	5.3
POWER BHP*	.5	2.0	.4	14.8	6.2	2.5
FUEL RATE, LB/HR	2.2	2.5	2.0	7.3	4.4	3.3
THROTTLE ANGLE, DEG	12.4	13.4	12.6	18.8	15.7	13.9
CONCENTRATIONS, DRY BASIS						
CO, %	.0976	.0276	.0360	.0255	.0312	.0336
CO2, %	2.08	2.53	2.07	6.17	3.58	2.79
O2, %	17.17	17.17	17.71	12.34	15.43	16.76
HC, PPMC	2553	479	457	409	306	288
NOX, PPM	28	66	43	210	113	77
SMOKE % OPACITY	.0	.0	.0	1.5	1.5	1.5
EMISSION RATES, G/HR						
CO	82.3	24.2	31.3	27.7	34.3	35.8
HC	106.2	20.7	19.6	21.8	16.6	15.1
NOX+	3.5	8.6	5.5	34.0	18.5	12.4
OIL TEMPERATURE, F	184	200	197	217	210	209
OIL PRESSURE, PSI	60	63	66	65	72	71
COOLANT TEMPERATURE, F	173	177	176	183	181	181
EXHAUST PRESSURE, IN. H2O	3.0	8.0	8.0	13.0	12.0	9.0
EXHAUST TEMPERATURE, F	260	290	249	616	385	321
EXHAUST FLOW RATE, LB/HR	158.4	195.7	195.3	248.0	250.4	252.5

* CORRECTED SAE J816B
+ CORRECTED FOR HUMIDITY

ENGINE: 1978 VW 90-CID DIESEL
FUEL CODE: 7807

TEST NUMBER	92.01	93.01	94.01	96.01	97.01	98.01
DATA SOURCE CODE	1	1	1	1	1	1
TEST DATE	2/22/78	2/22/78	2/22/78	2/22/78	3/22/78	2/22/78
BAROMETER, MMHG	745.5	745.5	745.5	745.5	745.5	745.5
HUMIDITY, GRAINS/LB	39	39	39	39	39	39
TEMPERATURE, F	76	76	77	76	76	79
ENGINE SPEED, RPM	2500	3000	3000	3000	3000	3500
TORQUE, FT-LB	2.6	40.9	32.7	5.5	1.2	42.0
POWER, BHP*	1.2	22.9	18.3	3.1	.7	27.5
FUEL RATE, LB/HR	3.1	11.4	9.5	4.6	3.4	13.7
THROTTLE ANGLE, DEG	13.5	23.0	21.3	14.7	13.0	25.3
CONCENTRATIONS, DRY BASIS						
CO, %	.0339	.0357	.0348	.0332	.0324	.0745
CO2, %	2.56	7.86	6.48	3.02	2.25	8.22
O2, %	16.99	9.86	11.57	16.14	16.99	9.83
HC, PPMC	273	359	335	217	222	611
NOX, PPM	67	288	274	107	65	328
SMOKE, % OPACITY	1.0	1.5	1.0	.5	.5	2.0
EMISSION RATES, G/HR						
CO	36.3	47.1	46.3	45.3	44.3	112.3
HC	14.4	23.3	22.0	14.6	15.0	45.4
NOX+	10.8	57.4	55.0	22.0	13.3	74.6
OIL TEMPERATURE, F	207	221	228	217	215	229
OIL PRESSURE, PSI	73	76	74	83	83	82
COOLANT TEMPERATURE, F	179	184	184	180	180	185
EXHAUST PRESSURE, IN. H2O	9.0	20.0	20.0	15.0	13.0	31.0
EXHAUST TEMPERATURE, F	302	755	663	344	286	817
EXHAUST FLOW RATE, LB/HR	246.9	305.0	304.1	306.1	307.0	356.6

* CORRECTED SAE J816B
+ CORRECTED FOR HUMIDITY

ENGINE: 1978 VW 90-CID DIESEL
FUEL CODE: 7807

TEST NUMBER	99.01	100.01	101.01	102.01	103.01	104.01
DATA SOURCE CODE	1	1	1	1	1	1
TEST DATE	2/22/78	2/22/78	2/22/78	2/22/78	2/22/78	2/22/78
BAROMETER, MMHG	745.5	745.5	745.5	745.5	745.5	745.5
HUMIDITY, GRAINS/LB	38	38	38	38	43	43
TEMPERATURE, F	79	77	76	76	78	78
ENGINE SPEED, RPM	3500	3500	3500	3500	4500	4500
TORQUE, FT-LB	33.6	14.0	5.6	.8	39.0	31.0
POWER, BHP*	22.0	9.2	3.7	.5	32.8	26.1
FUEL RATE, LB/HR	11.3	7.2	5.5	4.3	17.9	15.3
THROTTLE ANGLE, DEG	22.6	17.2	15.0	13.3	25.2	22.8
CONCENTRATIONS, DRY BASIS						
CO, %	.0428	.0315	.0310	.0362	.0999	.0823
CO2, %	6.91	4.21	3.18	2.49	8.87	7.48
O2, %	11.56	15.11	16.34	17.13	9.06	10.58
HC, PPMC	417	185	155	164	723	658
NOX, PPM	299	197	130	84	418	443
SMOKE, % OPACITY	1.5	1.0	.0	.0	6.0	5.0
EMISSION RATES, G/HR						
CO	63.7	49.3	48.3	56.4	182.1	152.2
HC	30.6	14.3	11.9	12.6	65.0	60.0
NOX+	66.9	46.3	30.6	19.6	116.1	124.8
OIL TEMPERATURE, F	238	231	228	226	236	255
OIL PRESSURE, PSI	76	83	85	85	89	82
COOLANT TEMPERATURE, F	186	186	180	180	188	186
EXHAUST PRESSURE, IN. H2O	29.0	22.0	21.0	20.0	48.0	45.0
EXHAUST TEMPERATURE, F	718	457	374	319	896	791
EXHAUST FLOW RATE, LB/HR	354.1	353.7	357.4	358.1	447.3	445.6

* CORRECTED SAE J816B
+ CORRECTED FOR HUMIDITY

ENGINE: 1978 VW 90-CID DIESEL
FUEL CODE: 7807

TEST NUMBER	105.01	106.01	107.01	108.01	112.01	113.01
DATA SOURCE CODE	1	1	1	1	1	1
TEST DATE	2/22/78	2/22/78	2/22/78	2/22/78	2/22/78	3/ 9/78
BAROMETER, MMHG	745.5	745.5	745.5	745.5	745.5	744.0
HUMIDITY, GRAINS/LB	43	43	43	43	43	34
TEMPERATURE, F	77	76	76	77	77	75
ENGINE SPEED, RPM	4500	4500	4500	5000	5000	5200
TORQUE, FT-LB	13.0	5.2	.8	38.3	.5	47.0
POWER BHP*	10.9	4.4	.7	35.8	.5	45.8
FUEL RATE, LB/HR	9.9	8.2	6.5	20.3	8.4	28.7
THROTTLE ANGLE, DEG	15.2	13.4	12.0	28.3	12.6	38.0
CONCENTRATIONS, DRY BASIS						
CO, %	.0551	.0511	.0503	.1094	.0947	.0050
CO2, %	4.72	3.83	3.10	9.42	3.68	12.95
O2, %	14.24	15.33	16.18	7.78	15.26	3.03
HC, PPMC	218	185	161	709	349	212
NOX, PPM	251	190	129	408	119	458
SMOKE, % OPACITY	3.0	4.0	3.5	5.0	4.0	.0
EMISSION RATES, G/HR						
CO	104.2	98.2	95.2	213.0	190.8	10.1
HC	20.3	17.5	15.0	68.0	34.7	21.2
NOX+	72.2	55.5	37.1	121.0	36.5	138.6
OIL TEMPERATURE, F	248	247	245	256	257	260
OIL PRESSURE, PSI	85	86	87	84	86	84
COOLANT TEMPERATURE, F	184	182	180	186	181	187
EXHAUST PRESSURE, IN. H2O	36.0	34.0	32.0	56.0	40.0	21.0
EXHAUST TEMPERATURE, F	546	469	409	959	513	1280
EXHAUST FLOW RATE, LB/HR	443.3	443.1	443.1	470.0	463.3	485.6

* CORRECTED SAE J816B
+ CORRECTED FOR HUMIDITY

ENGINE: 1978 VW 90-CID DIESEL
FUEL CODE: 7807

TEST NUMBER	118.01	119.01	123.01	124.01	125.01	127.01
DATA SOURCE CODE	1	1	1	1	1	1
TEST DATE	2/23/78	2/23/78	2/23/78	2/23/78	2/24/78	2/24/78
BAROMETER, MMHG	748.7	749.9	748.7	748.7	739.5	739.5
HUMIDITY, GRAINS/LB	41	43	43	43	51	51
TEMPERATURE, F	77	77	76	77	81	76
ENGINE SPEED, RPM	1000	1650	2000	2000	2000	2000
TORQUE, FT-LB	.2	38.6	39.5	31.6	13.2	1.1
POWER, BHP*	.0	11.8	14.7	11.8	5.0	.4
FUEL RATE, LB/HR	1.1	5.6	6.9	5.6	3.3	2.0
THROTTLE ANGLE, DEG	4.4	17.5	18.2	16.5	13.6	11.6
CONCENTRATIONS, DRY BASIS						
CO, %	.0460	.0404	.0299	.0291	.0260	.0298
CO2, %	2.23	7.64	7.56	6.31	3.37	2.01
O2, %	17.57	10.79	10.56	12.08	15.86	17.53
HC, PPMC	301	716	662	459	237	224
NOX, PPM	69	192	205	169	128	49
SMOKE, % OPACITY	.0	.0	.5	.0	.5	.0
EMISSION RATES, G/HR						
CO	19.5	27.0	24.8	23.6	23.3	26.9
HC	6.3	23.6	27.0	18.3	10.5	10.0
NOX+	4.4	19.5	25.9	20.9	17.8	6.9
OIL TEMPERATURE, F	179	171	203	205	203	197
OIL PRESSURE, PSI	36	71	59	56	60	64
COOLANT TEMPERATURE, F	170	173	180	182	179	175
EXHAUST PRESSURE, IN. H2O	.0	6.0	9.0	8.0	7.0	6.0
EXHAUST TEMPERATURE, F	225	633	686	586	355	241
EXHAUST FLOW RATE, LB/HR	95.7	158.1	196.4	195.1	195.5	194.2

* CORRECTED SAE J816B
+ CORRECTED FOR HUMIDITY

ENGINE: 1978 VW 90-CID DIESEL
FUEL CODE: 7807

TEST NUMBER	128.01	131.01	135.01	136.01	137.01	140.01
DATA SOURCE CODE	1	1	1	1	1	1
TEST DATE	2/24/78	2/24/78	2/24/78	2/24/78	2/24/78	2/24/78
BAROMETER, MMHG	739.5	739.5	739.5	739.5	739.5	739.5
HUMIDITY, GRAINS/LB	51	46	46	46	46	46
TEMPERATURE, F	77	76	77	77	76	77
ENGINE SPEED, RPM	2500	2500	3000	3000	3000	3500
TORQUE, FT-LB	39.6	5.3	13.6	5.5	1.2	14.0
POWER, BHP*	18.7	2.5	7.7	3.1	.7	9.2
FUEL RATE, LB/HR	9.1	3.2	5.4	4.1	3.3	6.9
THROTTLE ANGLE, DEG	19.4	12.6	15.0	13.1	12.0	16.1
CONCENTRATIONS, DRY BASIS						
CO, %	.0297	.0396	.0335	.0344	.0408	.0362
CO2, %	7.30	2.66	3.72	2.72	2.30	4.07
O2, %	10.37	17.15	15.60	16.77	17.33	14.90
HC, PPMC	315	244	230	237	252	220
NOX, PPM	224	64	157	89	67	186
SMOKE, % OPACITY	.0	.0	.0	.5	.0	1.5
EMISSION RATES, G/HR						
CO	33.6	43.1	43.8	46.2	52.2	55.9
HC	17.6	13.1	14.9	15.7	15.9	16.8
NOX+	39.5	10.7	31.4	18.4	13.0	44.0
OIL TEMPERATURE, F	214	210	225	221	218	235
OIL PRESSURE, PSI	66	70	75	78	80	82
COOLANT TEMPERATURE, F	184	179	180	179	179	180
EXHAUST PRESSURE, IN. H2O	14.0	12.0	17.0	16.0	15.0	5.0
EXHAUST TEMPERATURE, F	726	326	421	340	297	460
EXHAUST FLOW RATE, LB/HR	248.1	250.2	304.5	306.2	306.4	357.5

* CORRECTED SAE J816B
+ CORRECTED FOR HUMIDITY

ENGINE: 1978 VW 90-CID DIESEL
FUEL CODE: 7807

TEST NUMBER	142.01	144.01	145.01	146.01	147.01	148.01
DATA SOURCE CODE	1	1	1	1	1	1
TEST DATE	2/24/78	2/24/78	2/24/78	2/24/78	2/24/78	2/27/78
BAROMETER, MMHG	739.5	739.5	739.5	739.5	739.5	741.0
HUMIDITY, GRAINS/LB	46	46	46	46	46	61
TEMPERATURE, F	77	77	77	77	77	76
ENGINE SPEED, RPM	4500	4500	5000	5000	5000	1000
TORQUE, FT-LB	39.0	5.2	30.6	12.8	5.1	33.8
POWER, BHP*	33.1	4.4	28.8	12.1	4.8	6.4
FUEL RATE, LB/HR	17.5	7.9	17.1	11.0	9.0	3.1
THROTTLE ANGLE, DEG	23.0	12.7	26.2	21.5	20.6	10.8
CONCENTRATIONS, DRY BASIS						
CO, %	.0895	.0580	.0767	.0741	.0866	.0313
CO2, %	8.36	3.68	7.80	4.96	3.95	7.00
O2, %	9.33	15.71	10.15	13.91	15.15	11.21
HC, PPMC	686	270	495	366	347	340
NOX, PPM	431	183	358	228	143	177
SMOKE, % OPACITY	4.0	2.0	2.0	1.5	1.5	.5
EMISSION RATES, G/HR						
CO	169.1	112.3	151.9	147.6	176.0	12.6
HC	63.9	25.8	48.3	36.0	34.8	6.8
NOX+	124.6	54.3	108.6	69.7	44.6	11.3
OIL TEMPERATURE, F	240	249	261	262	258	181
OIL PRESSURE, PSI	87	85	83	83	85	35
COOLANT TEMPERATURE, F	187	181	187	182	182	181
EXHAUST PRESSURE, IN. H2O	48.0	.0	51.0	45.0	43.0	2.0
EXHAUST TEMPERATURE, F	877	488	851	629	543	480
EXHAUST FLOW RATE, LB/HR	445.7	440.8	465.3	461.5	461.8	93.4

* CORRECTED SAE J816B
+ CORRECTED FOR HUMIDITY

ENGINE: 1978 VW 90-CID DIESEL
FUEL CODE: 7807

TEST NUMBER	149.01	156.01	157.01	159.01
DATA SOURCE CODE	1	1	1	1
TEST DATE	2/27/78	2/27/78	2/27/78	3/ 6/78
BAROMETER, MMHG	741.0	740.0	740.0	745.0
HUMIDITY, GRAINS/LB	46	46	42	33
TEMPERATURE, F	76	76	76	74
ENGINE SPEED, RPM	1000	1000	1000	1650
TORQUE, FT-LB	27.1	18.2	18.0	30.9
POWER, BHP*	5.1	3.4	3.4	9.5
FUEL RATE, LB/HR	2.7	2.0	1.9	4.8
THROTTLE ANGLE, DEG	10.0	7.7	8.0	16.4
CONCENTRATIONS, DRY BASIS				
CO, %	.0363	.0301	.0334	.0463
CO2, %	5.80	4.56	4.62	5.87
O2, %	12.81	15.34	15.48	12.62
HC, PPMC	429	349	505	857
NOX, PPM	141	138	143	154
SMOKE % OPACITY	.0	.0	.0	.0
EMISSION RATES, G/HR				
CO	15.4	12.2	12.3	34.0
HC	9.0	7.0	9.2	31.1
NOX+	9.1	8.6	8.0	16.8
OIL TEMPERATURE, F	181	182	177	188
OIL PRESSURE, PSI	36	34	38	55
COOLANT TEMPERATURE, F	176	177	173	179
EXHAUST PRESSURE, IN. H2O	2.0	3.0	3.0	4.0
EXHAUST TEMPERATURE, F	418	336	348	519
EXHAUST FLOW RATE, LB/HR	95.8	96.2	95.5	156.8

* CORRECTED SAE J816B
+ CORRECTED FOR HUMIDITY

ENGINE: 1978 VW 90-CID DIESEL MOTORING DATA
FUEL CODE: 7807

TEST NUMBER	164.01	165.01	166.01	167.01	168.01	169.01
DATA SOURCE CODE	1	1	1	1	1	1
TEST DATE	3/16/78	3/16/78	3/16/78	3/16/78	3/16/78	3/16/78
BAROMETER, MMHG	753.8	753.8	753.8	753.2	753.2	753.2
HUMIDITY, GRAINS/LB	39	67	39	39	39	39
TEMPERATURE, F	74	74	74	74	74	74
ENGINE SPEED, RPM	1000	1500	2000	1000	1500	2000
TORQUE, FT-LB	-20.0	-22.4	-23.4	-20.2	-21.4	-23.8
POWER, BHP*	3.7	6.1	8.6	3.7	5.9	8.8
FUEL RATE, LB/HR	.2	.0	.0	.0	.0	.1
THROTTLE ANGLE, DEG	.5	.5	.5	.5	.5	.5
CONCENTRATIONS, DRY BASIS						
CO, %	.0305	.0032	.0152	.0000	.0000	.0000
CO2, %	.17	.08	.14	.01	.01	.01
O2, %	20.61	20.78	20.70	21.00	21.00	21.00
HC, PPMC	1128	469	705	1	1	1
NOX, PPM	6	3	3	1	1	1
SMOKE, % OPACITY	.0	.0	.0	.0	.0	.0
EMISSION RATES, G/HR						
CO	18.9	.0	.4	.0	.0	.0
HC	34.6	.0	.8	.0	.0	.4
NOX+	.5	.0	.0	.0	.0	1.2
OIL TEMPERATURE, F	174	171	176	180	184	184
OIL PRESSURE, PSI	39	66	85	36	55	75
COOLANT TEMPERATURE, F	165	165	167	173	173	172
EXHAUST PRESSURE, IN. H2O	1.0	1.0	1.0	1.0	1.0	1.0
EXHAUST TEMPERATURE, F	173	100	94	80	82	89
EXHAUST FLOW RATE, LB/HR	57.5	.0	202.2	.0	.0	202.2

* CORRECTED SAE J816B
+ CORRECTED FOR HUMIDITY

HE 18.5
.A34
no.DOT-TSC-
NHTSA-
79-6

BORROWER

00347487

U.S. DEPARTMENT OF TRANSPORTATION
RESEARCH AND SPECIAL PROGRAMS ADMINISTRATION
TRANSPORTATION SYSTEMS CENTER
KENDALL SQUARE, CAMBRIDGE, MA. 02142

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF TRANSPORTATION
613

U.S.MAIL

Performance characteristics of automotive engines in the United St
Koehler, Don E;United States. Energy Technology Center, Bartlesv
National Transportation Library, United States Department of Tran
[103] performancechara00koeh_7
DOT-TSC-NHTSA-79-6
Aug 17, 2015